

Research article - Basic and applied anatomy

# Morphometric study of variations of sacral hiatus among West Bengal population and clinical implications

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## Abstract

The study was conducted on one hundred and seventeen human sacra to categorize the sacral hiatus of West Bengal population to improve the accuracy of caudal epidural block for anesthesia and analgesia. Various contours of hiatus were observed in this study which included inverted U (70.09%), inverted V (14.53%), irregular (12.82%), bifid (1.71%) and dumbbell (0.85%). The most frequently observed positions of apex and base of the hiatus were fourth and fifth sacral vertebrae respectively (74.36% and 95.73%). The average length, width and depth of hiatus were 20.21 mm, 12.10 mm and 6.02 mm with standard deviation of 7.7 3mm, 3.13 mm and 2.43 mm respectively. All the measurements were taken by Vernier calipers. Only in 27.35% cases the points on the lateral sacral crests at the level of first sacral foramina formed an equilateral triangle with the apex of the hiatus and thus could be used as an important landmark to locate sacral hiatus.

## Key words

Sacrum, sacral hiatus, caudal epidural block, sacral cornua

## Introduction

Caudal epidural block (CEB) is used for analgesia and anaesthesia in various clinical procedures where the medication is injected into the epidural space through the sacral hiatus (Chen et al., 2004). This approach to epidural space produces reliable and effective block of sacral nerves.

The opening present at the caudal end of sacral canal is known as sacral hiatus, which is formed due to failure of fusion of laminae of fifth (occasionally fourth) sacral vertebra. The sacral canal contains sacral and spinal nerve roots, the cauda equina, filum terminale externum, fibrous and fatty tissue, epidural venous plexus and spinal meninges (Standring et al., 2008).

In practice, the sacral hiatus is identified by palpation of the sacral cornua keeping the patient in the lateral position or lying prone over a pelvic pillow. These are felt at the upper end of the natal cleft 0.5 cm above the tip of the coccyx. Alternatively, the sacral hiatus may be identified by constructing an equilateral triangle based on a line joining the posterior superior iliac spines (Standring et al., 2008). Posterior superior

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iliac spines impose over the lateral sacral crest at the level of first sacral foramina (Senoglu et al., 2005).

There are considerable variations in the size and shape of sacral hiatus which cause difficulty in localization of hiatus during CEB (Sekiguchi et al., 2004).

So, the purpose of this study was to explore the variations of sacral hiatus among the West Bengal population to increase the success rate of CEB. Moreover, the authors were also inquisitive to verify the significance of the aforesaid triangle for locating sacral hiatus among the study population.

## Materials and Methods

Completely ossified human sacra of undetermined age and sex were collected from different medical colleges of West Bengal during a study period of one year. Sacrum with total posterior closure defect (two cases) and agenesis of hiatus (one case) were excluded and finally the sample size was one hundred and seventeen. The shape, apex and base of sacral hiatus were noted. Length, depth and intercornual width of hiatus were measured by Vernier calipers. The gap between the two points of lateral sacral crests at the level of first sacral foramina and the distance of those points from the apex of the sacral hiatus were also measured. Finally, collected data was tabulated on Microsoft Excel Spread Sheet and analyzed by Epi info 3.5.1 software (CDC, Atlanta, GA).

## Results

Inverted U was the commonest shape of sacral hiatus and dumbbell was the rarest variant. The result is portrayed in Table 1 and different varieties of sacral hiatus are demonstrated in Figures 1-5. The level of the apex of hiatus varied from S2 to S5. (Table 2) but its commonest position was against S4 (74.36% of cases). Base of sacral hiatus was present in the plane of 4<sup>th</sup> sacral segment in 5 (4.27%) sacra and at the level of the 5<sup>th</sup> sacral segment in 112 (95.73%) sacra.

Several morphometric measurements of the sacrum are depicted in Table 3.

The mean distance between the two points on lateral sacral crests at the level of first sacral foramina (base of triangle) was 62.38 mm with standard deviation 6.19 mm. The average distances of those two points on right and left lateral sacral crests from the apex of the sacral hiatus were 63.38 mm (with standard deviation 9.21 mm) and 63.50 mm (with standard deviation 9.20 mm) respectively. A complete equilateral triangle was demonstrated in 32 cases (27.35%) by union of right and left lateral sacral crests with apex of hiatus. An isosceles triangle was observed in 74 cases (63.25%) and a scalene triangle was present in 11 cases (9.40%).

**Table 1** – Different types of sacral hiatus (n=117).

Inverted U	Inverted V	Irregular	Bifid	Dumbbell
82 (70.09%)	17 (14.53%)	15 (12.82%)	02 (1.71%)	01 (0.85%)

**Table 2** – Location of the apex of sacral hiatus (n=117).

2 <sup>nd</sup> sacral vertebra	3 <sup>rd</sup> sacral vertebra	4 <sup>th</sup> sacral vertebra	5 <sup>th</sup> sacral vertebra
2 (1.71%)	20 (17.09%)	87 (74.36%)	8 (6.84%)



**Figure 1** – Bifid sacral hiatus.



**Figure 2** – Dumbbell shaped sacral hiatus.



**Figure 3** – Inverted U shaped sacral hiatus.



**Figure 4** – Inverted v shaped sacral hiatus.



**Figure 5** – Irregular sacral hiatus.

**Table 3** – Morphometric measurements of the sacrum.

Parameter (mm)	Mean (mm)	Range (mm)	Standard Deviation (mm)	Mode (mm)
Length of sacral hiatus	20.21	8.80-54.00	7.73	15.00
Width of sacral hiatus	12.10	6.00-21.10	3.13	12.00
Depth of sacral hiatus	6.02	2.00-12.50	2.43	5.00
Distance between right and left lateral sacral crest at the level of first sacral foramina	62.38	46.60-89.10	6.19	62.00
Distance between right lateral sacral crest and apex of sacral hiatus	63.38	37.50-84.10	9.21	60.00
Distance between left lateral sacral crest and apex of sacral hiatus	63.50	37.50-84.10	9.20	60.00

## Discussion

Edward et al. (1942) for the first time took the advantage of this natural gap at the lower end of sacral canal for continuous caudal analgesia during labor (Edwards et al., 1942). Tsui et al. (1999) and subsequently Chen et al. (2004) stated that the use of ultrasound to guide needle placement into the caudal epidural space during CEB would increase the success rate by 100%. However, using ultrasound or fluorosco-

py is not always possible due to time, cost-effectiveness and personnel availability (Senoglu et al, 2005). So when ultrasound or fluoroscopy cannot be applied, other anatomical landmarks are used. But a failure rate of 25% has been reported by some investigators (Lewis et al., 1992 & Tsui et al., 1999). Stitz and Sommer (1999) reported a success rate, without fluoroscopy, of 74%. White et al., 1980 reported a failure rate of 25% in caudal epidural steroid injection.

U shaped sacral hiatus was predominant (70.09%) among the West Bengal population which was favorable for CEB. This finding supported the observation of Bhattacharya et al. (2013) where the authors reported the same type of hiatus (65%) among the identical population.

In the present study, the commonest position of the apex of the sacral hiatus was against the fourth sacral vertebrae (74.36%) which supported the similar observations of Kumar et al. (2009: 72.01%), Suma et al. (2011: 77.50%) and Sultana et al. (2014: 74.21%). Base of sacral hiatus was most often located against the fifth sacral vertebra (95.73%, which was close to the value of Sultana et al., 2014: 96.84%).

Previous studies (Patel et al., 2011; Aggarwal et al., 2012; Shewale et al., 2013) showed the average length of the hiatus to vary from 18.81 mm to 22.87 mm which was similar to the present study (20.21 mm). But the study by Patil et al. (2012) and Bhattacharya et al. (2013) described higher average values (34.13 mm and 35.92 mm) than the current study.

Sacral cornua were considered as an important landmark for identifying sacral hiatus. Variations in sacral cornua ranging from well-defined projection to flattening may greatly affect their utility for locating hiatus. In this study, the range of transverse width of the sacral hiatus or the intercornual distance (6-21.1 mm) was similar to the result of Aggarwal et al. (2009: 6-23.3 mm).

The antero-posterior diameter or the depth of sacral hiatus at the apex is very important as it should be sufficiently large to admit a needle into the sacral canal. In the present study it was less than 3 mm in 6.84% cases, where it would be difficult to insert a 22G needle. Trotter and Letterman (1944) and later Aggarwal et al. (2009) noticed this finding in 5% and 8.7% cases respectively.

As the apex of the sacral hiatus is difficult to palpate, especially in obese patients, other landmarks may be of use, such as the triangle formed between the posterior superior iliac spines or the lateral sacral crest and the apex of sacral hiatus (Senoglu et al., 2005). Aggarwal et al. (2012) and Patil et al. (2012) reported an equilateral triangle in 45% and 23% cases respectively. On the contrary, Bhattacharya et al. (2013) observed an isosceles triangle in general, but a complete equilateral triangle was found only in 16% cases. The present study described a scalene triangle (9.40%) in addition to isosceles triangle (63.25%) and complete equilateral triangle (27.35%) which was a unique finding of the study.

## Conclusion

The present study reports instances of shallow sacral canal at the apex (less than 3 mm) and abnormal shape of hiatus (*i.e.* irregular, bifid and dumbbell) where needle insertion may lead to failure. The right and left lateral sacral crests at the level of first sacral vertebra and the apex of hiatus formed a variety of triangle types which

were not reliable for caudal epidural block among the West Bengal population. The study also describes the possible anatomical causes of failure which should always be kept in mind while attempting caudal epidural block.

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